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# Biological Control of Yellow Starthistle (*Centaurea solstitialis*) in the Salmon River Canyon of Idaho

Jennifer L. Birdsall and George P. Markin*

Yellow starthistle is an invasive, annual, spiny forb that, for the past 30 yr has been steadily advancing up the Salmon River Canyon in west central Idaho. In 1994, a decision was made to attempt to manage yellow starthistle by establishing a complex of biological control agents in a containment zone where the weed was most dense. Between 1995 and 1997, six species of seedhead-attacking insects were introduced and successfully established. By 1999, the insects had spread through the entire containment zone. Following this dispersal, a rapid buildup of insect populations occurred, and, since 2003, seed destruction has fluctuated around 90%. Vegetation monitoring plots, however, have shown no consistent decline in the overall population of yellow starthistle, indicating that the amount of seed produced is still sufficient to allow full replacement. However, county weed control personnel, who are responsible for surveying and destroying outlying populations of yellow starthistle beyond the containment zone, report that, during this period, the number of new, isolated pockets of yellow starthistle they are finding has dropped dramatically. This case study discusses how the biological control program partially met the objective of managing yellow starthistle by reducing the rate of advance of this weed in the Salmon River Canyon.

**Nomenclature:** Yellow starthistle, *Centaurea solstitialis* L. CESO3.

**Key words:** Seedhead-attacking insects, seed predation, weed containment zones.

Yellow starthistle (*Centaurea solstitialis* L.) is a taprooted, annual forb that has been the target of biological control efforts since the 1960s (Pitcairn et al. 2004; Turner et al. 1995). This exotic, invasive, annual weed is most noted for the long, needle-sharp spines that surround the seedhead. Introduced from Eurasia into California before the 20th century, yellow starthistle is now one of the most destructive weeds in that state and has spread into at least 40 other states and across the southern portion of Canada (Balciunas and Villegas 2007; Maddox et al. 1985; Wilson et al. 2003). It is listed as a weed in Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, and Washington (NRCS 2010). Yellow starthistle is also spreading within Idaho, with a major expansion in the west central part of the state, where the drier, low-altitude canyons of the Clearwater and Salmon rivers provide ideal habitats. Although the oldest and largest infestation in Idaho is in the Clearwater River drainage, for the past 30 yr, yellow starthistle has been steadily moving in a distinct front up the Salmon River Canyon. In 1994, the Salmon River Weed Management Area (SRWMA) was created to bring together federal, county, and private weed managers to develop common objectives and to create weed-treatment programs, which included integrated management (Idaho State Department of Agriculture 2009). The SRWMA encompasses more than 218,531 ha (539,990 ac), with yellow starthistle infesting approximately 1,473 ha of the 24,888 ha surveyed (5.9%). Yellow starthistle mainly infests the northern part of the SRWMA between White Bird, ID, and Slate Creek and extends from the river (elevation 488 m [1,601 ft]), up each side of the canyon, to an approximate elevation of 1,220 m. The plant community primarily consists of yellow starthistle; introduced annual grasses, including bromes (field brome [*Bromus arvensis* L.] and downy brome [*Bromus tectorum* L.]), ventenata [*Ventenata dubia* (Leers) Coss. in Dur.], and medusahead [*Taeniatherum caput-medusae* (L.) Nevski]; bluebunch wheatgrass [*Pseudoroegneria spicata* (Pursh) A. Löve]; balsamroot (*Balsamorhiza* spp.); lomatium (*Lomatium* spp.); and yarrow (*Achillea* spp.). Above 1,220 m the habitat changes to timbered slopes which are more resistant to the advance of this weed.

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In 1994, SRWMA initiated a program to prevent the further spread of yellow starthistle. Because of the difficult access to the two canyon walls, conventional spraying would have been impractical. Instead, the U.S. Department of Agriculture (USDA), Forest Service (Nez Perce National Forest at Grangeville, ID), enlisted the services of the Rocky Mountain Research Station's Weed Biological Control Program in Bozeman, MT, to determine whether biological control agents could be established in an effort to destroy seed production, which might reduce the rate of yellow starthistle spread up the canyon. A containment area between White Bird, ID, and Skookumchuck Creek was designated for biological control. At the same time, the SRWMA would concentrate their spraying efforts on locating and treating the isolated pockets between Skookumchuck Creek and Slate Creek, which were located beyond the containment zone. From 1995 through 1997, six species of insects, obtained from southwestern Oregon, were introduced and successfully established in this containment zone. This article presents the results of our monitoring of the population increases of the six insects, their effect on seed production and on the existing population of yellow starthistle, and our observations on the rate of advance of yellow starthistle beyond the containment zone.

## Materials and Methods

**Introduction and Establishment of Biological Control Agents Within the Containment Zone.** At the beginning of this study, five species of insects had been evaluated by the USDA Agricultural Research Service (ARS) and approved by the USDA Animal and Plant Health Inspection Service (APHIS) for use as biological control agents for yellow starthistle (Pitcairn et al. 2004; Turner et al. 1995). These insects had been released and were well established in California; populations had been moved north and were well established in the drier, warmer interior valleys of southwestern Oregon. One of these insects, the weevil *Bangastemus orientalis* Capiomont [Coleoptera: Curculionidae], was released and established in the Clearwater Canyon near Lewiston, ID. In planning our program, an informal agreement was made with Dr. Joseph McCaffrey, Professor of Entomology at the University of Idaho, who would introduce and release the other biological control agents in the Clearwater Canyon; the USDA Forest Service accepted responsibility for the Salmon River Canyon. *Bangasternus orientalis* was collected in the Clearwater Canyon in 1995 and was the first insect released into our containment zone. The USDA Forest Service then obtained the necessary permits so that the other biocontrol agents could legally be collected near Roseburg and Grants Pass, OR, at sites identified by the Oregon Department of Agriculture, and transported and released in Idaho. During 1996 and 1997, populations of two other seed-attacking weevils, *Eustenopus villosus* Boheman and *Larinus curtus* Hochhut [Coleoptera: Curculionidae], were collected during the summer by shaking yellow starthistle plants to dislodge the adult weevils onto plastic trays. During this period, approximately 3,000 adults of these two weevils (no effort was made to separate them by species) were released within the containment zone.

The remaining two insects introduced were the seedhead-feeding flies, *Urophora sirunaseva* Hering and *Chaetorellia australis* Hering [Diptera: Tephritidae]. Flies were collected from populations recommended by the Oregon Department of Agriculture because of their low rates of parasitism. Collecting and shipping adults turned out to be very difficult. Instead, populations of these flies were located during the summer when the adults were active, and in fall or early winter, closed seedheads containing fly prepupae and pupae were collected from these locations and shipped to Idaho. The seedheads were placed in the field at 100 locations within the containment zone, and the flies were allowed to overwinter naturally and emerge the following spring. To prevent the accidental introduction of seeds of the Oregon variety of yellow starthistle to Idaho, the seedheads were placed out in closed, plastic containers with openings around the tops for the emerging flies to escape. These containers confined the seedheads and were collected the following summer and destroyed after the flies emerged. Estimates from subsamples held in the laboratory indicated that approximately 100 adult flies of two species emerged from each container. Therefore, approximately 10,000 seedhead flies were introduced in the containment zone. Although we did not perform additional parasite rearing tests on the transferred populations as part of our study, observed rates of parasitism were very low.

After these releases were underway, it was discovered by the USDA ARS that, during their introduction of *Chaetorellia australis* into California, a second closely related species of seedhead fly, *Chaetorellia succinea* Hering, had been accidentally introduced (Balciunas and Villegas 1999). Because of host-specificity risks, no permit has been issued to approve this fly as a biological control agent (Balciunas and Villegas 2001, 2007). Upon checking our populations in the field, we discovered that we had also introduced this fly. Thus, we had six yellow starthistle seedhead-attacking insects released in the Salmon River containment zone.

**Monitoring Biological Control Agent Populations Within the Containment Zone.** To monitor the populations of the seedhead-attacking insects during the first 5 yr (1995 through 1999), we opened fall-collected seedheads from random locations throughout the infestation (usually close to points of release) and recorded the presence of seedhead-attacking insects. By 1999, it appeared that all six insects were established and increasing in number. In 2000, we decided that a more systematic monitoring method would be useful for tracking the further buildup and possible effect of these seedhead-attacking insects. We established seven insect sampling locations (eventually increased to 14) within the containment zone between White Bird, ID, and Skookumchuck Creek, although time restraints frequently prevented us from sampling all of the locations, which resulted in a yearly variation in the number of insect-sampling locations. We selected locations that were spaced at least one-half mile apart, had at least 0.4046 ha of relatively continuous yellow starthistle, and were accessible by vehicle. To sample a range of habitats, the selected locations ranged from the top of the yellow starthistle infestation on one side of the canyon, down to the canyon bottom, and to the top of the infestation on the other side of the canyon. After some initial trials, the final sampling method used at each of the locations was a randomly placed, straight transect, usually running upslope from the road. At 2-m intervals along this transect, an observer selected the closest multibranched plant on the right-hand side of the transect that had a minimum of 10 seedheads. Five of these seedheads were randomly selected, one from the topmost, terminal branch; two from lateral branches; and two interior seedheads. Sampling 20 locations along the transect resulted in 100 seedheads from each locality, which were placed in paper sacks. Seedheads were collected in early to mid fall (generally September or October) when yellow starthistle plants were senescing. Although seedhead production by yellow starthistle is indeterminate, with a steady production of heads throughout the season, the seedhead receptacles remain on the plants even after the heads open and disperse their seeds. By collecting both open and closed seedheads, we were able to determine the seasonal percentage of seedheads attacked by the insects. Open seedheads are unattacked. Although a seedhead remains closed after attack, closed seedheads can also be unattacked heads that have not yet opened and dispersed their seeds. Although fall sampling does not provide a seasonal average of total seed production because we cannot tally the seeds from open seedheads, we can determine the average number of seeds produced and the viability of these seeds in the closed seedheads.

To monitor the effects of the seedhead-attacking insects, we randomly selected a minimum of 50 seedheads from each sack for dissection in the laboratory. Although the weevils had completed their development and exited, the feeding chambers formed in the seedheads remained and easily identified attacked plants. The feeding chambers of *E. villosus* were distinct enough that the presence of that species could be positively identified. The chambers of *B. orientalis* and *L. curtus* were so similar that they could not be separated; counts for those two insects were lumped together. In contrast to the weevils, all three species of flies overwinter in the seedheads. Both species of *Chaetorellia* overwintered as a prepupa within the pappus of the attacked seedhead and, because they could not be identified by species, our counts represent both species. Although *Chaetorellia* and *Urophora* are distinguishable, when we first began this program, we did not have the experience to identify these flies and, therefore, combined the counts between 1996 and 1999. As population numbers increased, our skill in identification also increased, and, in 2000, we began separating *Chaetorellia* sp. and *Urophora* sp. *Urophora sirunaseva* overwinters as a prepupa in a small, hard-shelled gall and can be identified easily. While the seedheads were being dissected, all seeds they contained were removed and examined. As the study progressed, increasing numbers of these seeds showed signs of feeding damage or were shrunken and misshapen. A germination test of these deformed seeds showed that most (95%+) were not viable. Therefore, although all seeds in the seedhead were removed and tallied, we identified only the undamaged, fully formed seeds as being viable. The estimated effects of the seedhead insects were based on the mean number and viability of seeds that we found in the seedhead samples from the plots.

**Monitoring Yellow Starthistle at Sites Within the Containment Zone.** In 1997, after we had confirmed that the insects were established but were still at very low numbers, six perimeter vegetation monitoring sites were established in the containment zone by vegetation management personnel from the Nez Perce National Forest (Figure 1). At each of the 7.62 by 12.19 m monitoring sites, 10 to 25 rectangular, 0.38 by 0.61-m quadrats were randomly selected per site. Yellow starthistle density, height of tallest plant, and percentage of cover formed by the plant canopy were recorded. In 1998, while most insect populations were still very low, Nez Perce Forest personnel repeated the vegetation sampling but only collected density data. We considered 1997 and 1998 our pretreatment, baseline samples. Besides sampling in the monitoring sites, visual inspections were made of the surrounding yellow starthistle populations to confirm that the vegetation sample plots represented the surrounding population. By 1999, the insect population had begun to explode and was presumably beginning to affect the yellow starthistle population so further ''pretreatment'' vegetation sampling was discontinued.

By 2006, it appeared that the insect colonization period was over and that a stable population equilibrium had been reached so ''posttreatment'' vegetation sampling was begun but, this time, by USDA Forest Service researchers from Bozeman, MT. In 2007, the six original vegetation-monitoring sites, which had been permanently marked

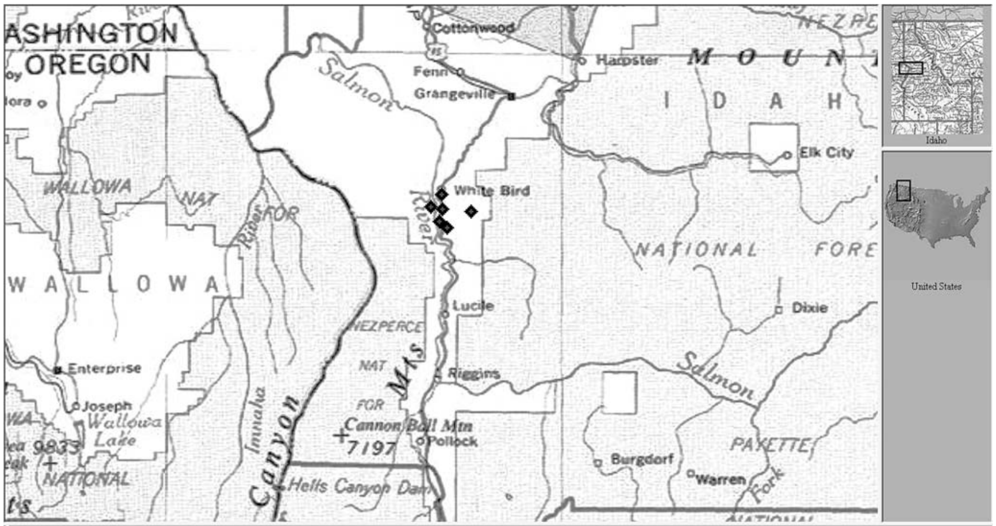


Figure 1. Yellow starthistle vegetation monitoring sites in the Salmon River Canyon Management Area.

with metal posts, were relocated and resampled using the same protocol and parameters as the two pretreatment readings. Because of the tremendous growth variability of yellow starthistle in response to rainfall, we repeated the vegetative sampling in 2008.

## Results and Discussion

**Establishment and Effect of Biological Control Agents.** Table 1 shows the population buildup of the four classes of insects that we could identify in the seedheads. Although seedhead damage by *B. orientalis* and *L. curtus* could not be separated, summer field observations of adult weevils over the course of this study indicated that populations primarily consisted of *B. orientalis*. *Larinus curtus*, although present, generally remained at very low levels. The two *Chaetorellia* species were also combined. Distinguishing adults of these species is difficult, but examination of flies that emerged from seedheads in the laboratory showed that both species were present, although their ratios fluctuated from year to year.

The percentage of seedheads attacked (based on the random samples throughout the area) showed a steady increase through 2003 (Table 1). From 2000, when the detailed sampling began, populations appeared to increase rapidly, until 2003, when they peaked with 92% of the seedheads being attacked. In 2004, rainfall in the early fall resulted in a flush of late flowers that escaped insect attack, lowering the percentage of seedheads attacked to 29.5%. In 2005, seedhead attack rose again to 72% and, since then (2006 and 2007), has remained around 90% (Table 1). Although, for the first 3 yr of the study, there appeared to be no detectable effect on seed production (based on the random samples), by 1998 and 1999, the insects were abundant enough that seed production was being reduced; therefore, in 2000, we initiated a systematic sampling of seedheads at set sampling locations. By 2002, the effect on seed production seemed to peak, with a mean of only 3.9 viable seeds seedhead$^{-1}$ compared with a mean of 36.0 viable seeds seedhead$^{-1}$ in 1995 (Table 1). Although the yearly average percentage of viable seeds produced fluctuated between 32 and 69% during the last 6 yr of the study (2002 through 2007), there was consistently less than the 81 to 100% viable seeds between 1995 and 2000. Thus, both the overall number of seeds produced and the percentage of viable seeds appear to have been reduced by the establishment of the seedhead insects.

All six seedhead insects successfully established and, within 5 yr, had increased to damaging population levels. The combined effect of the three weevils, which in some years affected 80% of the seedheads examined, had the largest effect because weevil feeding usually eliminated all seeds within the seedhead. Although the three fly species seemed to be the most numerous biological control agents early in the program, attacks by these species leveled off and peaked at more than 50% in 2001 and 2003; the frequency of attack has since declined (Table 1). Woods et al. (2008), in a study evaluating the effect of *U. sirunaseva* on yellow starthistle seed production at two study sites in Northern California, reported a similar decline of flies at one of their study locations. The effect has also been lessened because attacks by low numbers of seedhead flies in individual seedheads usually allow more viable seed to escape. The final figure of 3.7 viable seeds seedhead$^{-1}$ recorded in the last year of the survey (2007) represented a combination of seeds from nonattacked seedheads and those that escaped attack by the seedhead flies. Woods et al. (2008) reported that the flies did not reach levels needed to exert significant control of seed production. Although it was not specifically tested as part of our study (we had no way of identifying

Table 1. Seedhead-attacking insect population levels and their effects on yellow starthistle in the Salmon River Canyon Management Area.

| | | | Seedheads attacked (sorted by insect taxa) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Weevils | | Flies | | | | |
| Year | Insect sampling locations[a] | Seedheads examined | *Eustenopus* | *Bangasternus* and *Larinus* spp. | *Chaetorellia* spp. | *Urophora* | Total seedheads attacked | Mean seeds per closed seedhead | Mean viable seeds per closed seedhead |
| | No. | No. | % | % | % | % | % | No. | No. (% viable) |
| 1995 | — | 200 | 0 | 0 | ND | | 0 | 36.0 | 36.0 (100.0) |
| 1996 | — | 418 | 0 | 0.48 | 2.1 | | 2.5 | 29.0 | 27.5 (94.8) |
| 1997 | — | 201 | 0.25 | 0.25 | 2.5 | | 3.0 | 35.0 | 32.4 (92.6) |
| 1998 | — | 311 | 2.0 | 0.90 | 7.1 | | 11.3 | 23.9 | 21.0 (87.9) |
| 1999 | — | 148 | 7.7 | 17.0 | 11.5 | | 26.4 | 22.2 | 19.2 (86.5) |
| 2000 | 7 | 352 | 1.3 | 9.4 | 20.4 | 2.8 | 35.8 | 21.9 | 17.9 (81.7) |
| 2001 | 6 | 309 | 23.9 | 5.2 | 55.3 | 2.3 | 82.7 | ND | ND |
| 2002 | 11 | 586 | 24.9 | 18.3 | 35.7 | 0.7 | 79.5 | 7.8 | 3.9 (50.0) |
| 2003 | 12 | 627 | 19.3 | 14.6 | 57.6 | 0.5 | 92.0 | 9.0 | 6.2 (68.9) |
| 2004 | 10 | 536 | 8.9 | 6.3 | 10.8 | 3.4 | 29.5 | 10.5 | 5.0 (47.6) |
| 2005 | 12 | 746 | 12.5 | 27.3 | 18.1 | 14.3 | 72.2 | 16.6 | 8.2 (49.4) |
| 2006 | 7 | 485 | 41.4 | 40.0 | 13.2 | 1.4 | 96.1 | 11.9 | 8.1 (68.1) |
| 2007 | 14 | 893 | 42.8 | 22.2 | 22.8 | 2.3 | 91.7 | 11.8 | 3.8 (32.2) |

Abbreviation: ND, no data.

[a] Dashes (—) indicate no permanent sampling locations were set up until 2000, only random collections of seedheads.

the age of a seedhead or when a plant had flowered), we suspect that the 4 to 8% of the seedheads that were not attacked and which contributed most of the viable seed was probably from late-forming seedheads on plants that continued to flower after the peak of insect activity had occurred.

**Effect on Established Stands of Yellow Starthistle Within the Management Zone.** Our vegetation monitoring program was designed with the goal of detecting changes in plant populations within the containment zone. However, because of the variability between years, no consistent differences were evident for yellow starthistle densities, heights, or covers (Table 2). In the pretreatment years of 1997 and 1998, mean yellow starthistle densities differed in magnitude by almost 5 times (226 plants $m^{-2}$ [21 plants $ft^{-2}$]) in 1997; 1,052 plants $m^{-2}$ in 1998). Sheley and Larson (1994), who characterized the life history of yellow starthistle near Walla Walla, WA, also noted oscillatory patterns of community dynamics for yellow starthistle. These researchers suggested that yellow starthistle seed output was dependent on the availability of spring precipitation. When we examined precipitation data from the West Branch, ID, SNOTEL (snowpack telemetry operated by NRCS) site for the years 1996 through 1998 and 2006 through 2008, we did not detect differences in either total or average precipitation between the years (October through September) or during seedling germination periods (October through March, October through December, or January through March), which could account for the variations we observed. However, both total and average spring precipitation (April through June) was lower during 2006 to 2008 (total, 50.5 cm [19.897 in]; average, 5.6 cm) than during 1996 to 1998 (total, 93.7 cm; average, 10.7 cm). Recently, Hierro et al. (2009), in a study examining contrasting precipitation regimes within both native and nonnative ranges for yellow starthistle, determined that germination response and survival varies among populations and is dependent on a number of variables, including variations in winter conditions, such as precipitation and the interplay of winter and summer conditions. In our study, we found that the oscillations in yellow starthistle community dynamics present a challenge to developing a successful monitoring program that can detect the effects of biological control agents.

Although production of viable seed was reduced by approximately 90% by the end of the study, the surviving seeds were sufficient to replace and maintain the established populations of yellow starthistle within the containment zone. Similarly, in 2005 and 2006, at sites in Hells Canyon (on the Idaho and Oregon border), Winston and Schwarzländer (2008) reported seedhead attack levels of 80 to 93% at sites with the same six seedhead insects. Despite decreases of 27 to 58% in seed production, yellow starthistle density increased, and the researchers concluded that the seed bank was not sufficiently impaired to cause

Table 2. Results of monitoring yellow starthistle (YST) in the Salmon River Canyon Management Area.

| Year | Quadrats | Mean ± SE YST density | Mean ± SE YST height | YST cover | Coverage by annual grasses | Coverage by perennial grasses | Coverage by forbs | Coverage by shrubs |
|---|---|---|---|---|---|---|---|---|
| | No. | No. 0.23 $m^{-2}$ | m | % ± SE | | | | |
| 1997 | 110 | 51.98 ± 4.02 | 0.606 ± 0.020 | 35.59 ± 1.70 | 10.70 ± 1.04 | 1.53 ± 0.43 | 11.85 ± 1.19 | 0.14 ± 0.10 |
| 1998 | 133 | 242.42 ± 10.70 | ND | ND | ND | ND | ND | ND |
| 2007 | 120 | 56.30 ± 5.34 | 0.266 ± 0.014 | 15.85 ± 0.99 | 12.97 ± 1.32 | 1.65 ± 0.43 | 3.54 ± 0.37 | 0.75 ± 0.61 |
| 2008 | 120 | 17.49 ± 1.72 | 0.450 ± 0.014 | 14.85 ± 0.88 | 24.75 ± 1.37 | 0.92 ± 0.40 | 6.34 ± 0.57 | 0.52 ± 0.39 |

Abbreviation: ND, no data.

reductions in yellow starthistle populations. Other researchers also report that biological control agents have not reduced yellow starthistle populations to acceptable levels (Balciunas and Villegas 1999; DiTomaso and Gerlach 2000; Garren and Strauss 2009; Pitcairn et al. 2000, 2006; Turner and Fornasari 1992). However, long-term studies on biological control of spotted [*Centaurea stoebe* L. subsp. *micranthos* (Gugler) Hayek] and diffuse (*Centaurea diffusa* Lam.) knapweeds show that, although agents that reduce seed production may not initially reduce plant densities, they can result in significant weed control over time, particularly in combination with agents that attack other life stages of the weed (Myers et al. 2009; Story et al. 2008). Other studies have shown that the effectiveness of predispersal seed predation at reducing population size varies among plant species (Garren and Strauss 2009; van Klinken et al. 2008).

## Management Implications

Interestingly, the personal observations of the local county spray crew responsible for surveying and treating the lands outside the yellow starthistle containment zone are that the reduced seed production may have slowed the spread of this weed because the discovery of new infestations ahead of the front has dramatically declined over the period of the study. Carl Crabtree, the Idaho County Weed Supervisor, maintains that our program has been effective at noticeably slowing the spread of yellow starthistle up the Salmon River Canyon. Although seed predators often do not cause significant population regulation of invasive plants, they may affect invasion rates (defined as the combined effects of spread and infill), although this has proved difficult to demonstrate empirically (Shea et al. 2010; van Klinken et al. 2008). Using models, these researchers found that invasion rates are sensitive to seed reductions and that commonly observed seed-predation rates may be sufficient to result in significantly reduced invasion rates. They suggest that, in biological control programs, seed predators should be released as early as possible in the invasion process. Our study suggests that this strategy may slow the invasion rate of yellow starthistle, which is an undervalued benefit of biological control programs, which are often judged solely on whether there is a substantial decline in the overall abundance of the target weed (Hoffman and Moran 2008).

A decline in the invasion rate of a noxious weed can result in reduced expenditures of time and money spent on locating and treating infestations. Furthermore, because effective control is sometimes dependent on establishing a complex of biological control agents, agents that provide partial control may represent a valuable, or even necessary, component of a successful biological control program. Similarly, agents that provide partial control can be used in conjunction with integrated management programs (which include chemical and cultural control measures) to enhance the effectiveness of these programs (Collier et al. 2007; Huwer et al. 2005; Jongejans et al. 2006; Lym 2005). Thus, although the seedhead-attacking insects did not result in complete control of yellow starthistle, we argue that they are likely beneficial, particularly when released early in the weed invasion process. Whether the benefits of slowing the spread of an invasive, exotic weed outweigh the economic costs and potential ecological risks of introducing seedhead-feeding biological control agents continues to be a question for debate.

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During this study, Joe McCaffrey from the University of Idaho worked simultaneously to establish the same biological control agents in the Clearwater drainage. We extend a tremendous thanks to Joe McCaffrey for his participation and support of our work in the Salmon River Canyon. On the Nez Perce National Forest, we are grateful for the support that Leonard Lake and Don Sorenson, the local vegetation managers, provided us (particularly for providing crews instrumental in setting up and monitoring some of the vegetation plots). We also thank Leslie Eddington and Gregory Kalaris for help in monitoring the vegetation plots. Eric Coombs, Oregon Department of Agriculture, was a key player in our program and directed us to the locations in southwestern Oregon from which we collected the insect populations that we released in Idaho. We are very grateful for the continued support for this program from Carl Crabtree, Weed Management Supervisor for Idaho County from Grangeville, ID, for his observations on the advance of the yellow starthistle population along the front, and to those other invaluable members of the Salmon River Weed Management Consortium, who provided observations on which our conclusion of the effectiveness of this program was based. Finally, we thank Jack Butler and Justin Runyon of USFS Rocky Mountain Research Station for their reviews and suggestions.

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